Northeast Consortium Annual Report

Project Title: **Yellowtail Flounder Tagging Study**

Project Leader: Steve Cadrin
NOAA/UMass CMER Program
706 South Rodney French Boulevard
New Bedford, MA 02744-1221
(508) 910-6358
(508) 910-6371 fax
Steven.Cadrin@noaa.gov

Periods of Performance: FY 2003 grant, October 2003-September 2004
FY 2004 grant, October 2004-September 2005
FY 2005 grant, October 2005-September 2006

Date of Submission: July 1, 2008

Primary Participants

Steve Cadrin
NOAA/UMass CMER Program
706 South Rodney French Boulevard
New Bedford, MA 02744-1221
(508) 910-6358
(508) 910-6371 fax
Steven.Cadrin@NOAA.gov

David Goethel, F/V Ellen Diane
23 Ridgeview Terrace
Hampton, NH 03842
603 926-2165
EGoethel@comcast.net

Fred Mattera, F/V Travis & Natalie
113 Lewiston Avenue
West Kingston, RI 02892
401 364-7994
fm@nestco.necoxmail.com

Josh Moser
Northeast Fisheries Science Center
166 Water Street
Woods Hole MA 02543
508 495-2246
508 495-2393 fax
Joshua.Moser@NOAA.gov

Larry Alade
166 Water Street
Woods Hole MA 02543
508 495-2085
508 495-2393 fax
Larry.Alade@NOAA.gov

Project Objectives

There are several objectives of the Yellowtail Flounder Tagging Study:

- estimate movement rates among yellowtail fishing grounds
- provide independent estimates of mortality for each stock area
- confirm age determinations
- foster cooperative relationships between scientists and fishermen.

The general approach is based on an experimental design that represents the entire population and an analytical design that models simultaneous movement and mortality. Thereby, the experimental design corresponds to the analytical design, and population estimates support all three technical objectives (movement, mortality and growth) with one study.

All phases of the proposed research, from the field protocol to public outreach, have been developed cooperatively between New England groundfish fishermen, the Northeast Fisheries Science Center and other research agencies. Co-principal investigators represent fishermen from all three major fishing grounds (Georges Bank, Southern New England-Mid Atlantic and Cape Cod-Gulf of Maine). Based on the concerns of fishermen and researchers about uncertainty in stock assessments and the need for better understanding of yellowtail movements, a cooperative study has been designed to integrate several ongoing yellowtail tagging efforts.

Methods and Work Plan

This project contracts commercial fishermen and their vessels to work with scientists to tag and release yellowtail on all fishing grounds off New England, proportional to geographic patterns of abundance. The geographic design is based on statistical fishing areas, with releases in each area proportional to relative abundance of yellowtail (according to NEFSC groundfish surveys). Such a design allows for the estimation of movement among areas and mortality by area.

Tag Deployment

Yellowtail are captured using commercial otter trawls with large mesh (6.5") and relatively short tows (30 min). All legal-sized fish (>33cm) in viable condition, and some sublegal sized-fish from low density tows in southern New England-Mid Atlantic are tagged with either Peterson discs or data-storage tags. Releases are during the spawning season (May-August; with the exception of 1% of releases in autumn of 2003). Tag specifications are:

- Peterson Discs; Floy Tag 7/8" round, fluorescent pink, labeled "cooperative-tagging.org, tag#, $1000 lottery (or $100 reward), toll free 877-826-2612, provide tags & location and date." Most fish tagged blank on blind side, scales plucked from approximately 10%, tags on blind side labeled "take some fish scales & return to 166 Water Street Woods Hole MA 02543."
- Data-storage tags; Lotek LTD 1100, 32K memory, 8mm x 16mm x 27mm; time (dynamic storage & intervals), depth (+/- 0.04psi up to 735psi) & temperature (+/- 0.19o C), 3 year battery, labeled "tag#, Mail tag, date, location to 166 Water Street Woods Hole MA 02543". Oval disc tag labeled "cooperative-tagging.org, $100 reward, toll free 877-826-2612."

Tag Recapture and Outreach System

Tag recaptures are from a year-round commercial fishery with some seasonal geographic closures. The reward system for reporting recaptures involves $1000 lottery tags, 280 high-value ($100) rewards, and $100 rewards for returning data-storage tags. The outreach system includes reward posters, brochures, website (cooperative-tagging.org), annual letters to yellowtail fishermen, press releases, and a toll free number (877-826-2612). Every fisherman who reports a recapture is contacted via a phone call and 'thank you' letter with a map detailing movements of the tagged fish. Fishermen who return data storage tags, also receive a graph of the temperature and pressure data from that tag. Mailings and posters about the program have also been distributed to fish processors, fishing associations, NMFS port agents, NMFS Observer Program and research institutions from Nova Scotia to New Jersey.
Project hats are given to leading tag returns and collaborators.

In response to suggestions at the 2nd Annual Yellowtail Tagging meeting (May 2 2005, Woods Hole), a new double-sided reward poster with information detailing the project was designed. The poster incorporated pictures of the new $100 yellow disk tag and new orange scale blanks. Posters

are translated in Portuguese, French and Spanish to foster better communication between scientists and fishermen in New Bedford and Canada. To compliment the new database, phone logs have been carefully revised to collect more information without compromising critical recapture information. Scale envelopes labeled with yellowtail tagging pertinent info have been distributed throughout the ports by key cooperators and through mailings. Discussions at the the 3rd Annual meeting (March 1 2006, New Bedford) focused on understanding recapture patterns and increasing outreach to fisheries that catch yellowtail incidentally.

Since the project began in 2003, 103 $100 rewards have been issued and nine $1000 lottery drawings have been hosted at fishing venues throughout New England. In addition to the standard "thank you" letters and maps, the project initiated an "Outstanding Partner" Award to the vessel with the most tag returns. A framed certificate and "thank you" letter signed by the Director of the NEFSC is mailed to the partner and posters announcing the merit are distributed for display in fishing supply houses and around the waterfront. This year, the award went to the F/V Voyager I out of New Bedford, MA (Captains Fred Marques and Tony Fernandes).

The toll free number for reporting tags (877-826-2612) is maintained and answered by a project coordinator at NEFSC. The website was updated to include more information and a flashy appearance. Several new features include a "Porthole Page", new stock assessments, a policy on lottery drawings and recent publications. The website is maintained and updated regularly with press releases, lottery winners, and data tag returns.

Analytical Design

The analytical model is based on the assumption that the observed pattern of recaptures is a function of harvest rate in each area and movement among areas. If the population of tagged yellowtail is representative of the entire population, the estimates of movement and mortality will also be representative. The analytical design will relate the observed number of tag returns (r) to a predicted number of tag returns:

$$1) \qquad \tilde{r}_i^t = n_i^t \beta_i^t \frac{F_i^t \left(1 - e^{-(F+M)}\right)}{\left(F_i^t + M\right)}$$

and tags at the beginning of a time step is a function of abundance at the beginning of the time step in all areas, movement to the area (or residence in the area) and survival:

$$2) \qquad n_i^{t+1} = S_j^t \sum_j \alpha_{ij}^t n_j^t$$

where

n_j^t is the number of tags present in area j at time t

β_i^t is the reporting rate in area i at time t.

F_i^t is the fishing mortality rate in area i at time t.

M is the natural mortality rate

$\alpha_{i,j}^t$ is the proportion of tags in area j that move to area i at time t

S_i^t is the survival in area i at time t [$S=e^{-(M+F)}$]

The parameter β_i^t can be calculated as the ratio of lottery tag returns to high value ($100) tag returns, assuming that all recaptures if $100 tags are reported. The parameters $\alpha_{i,j}^t$ (movement) and F_i^t (fishing mortality) can be estimated to fit model predictions to the observed frequency of seasonal returns by area.

The number of tag returns and the duration of the study will dictate how many parameters can be reliably estimated. The model has flexible spatiotemporal resolution, so that stock areas can be analyzed by statistical areas, and movements can be analyzed by season, if the number of tag returns supports such detail.

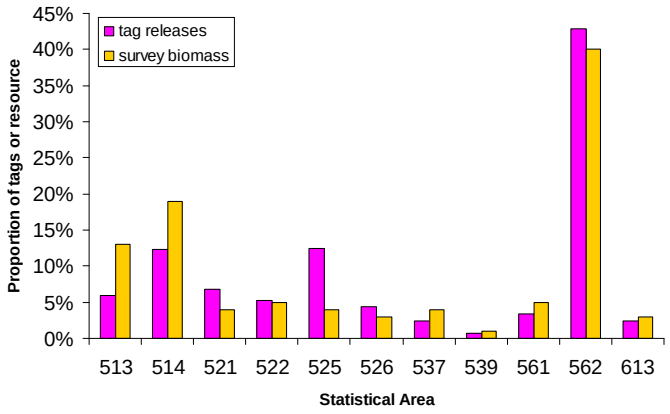
Work Completed to Date (*note: revised data based on recently audited database*)

Tagging began in 2003 from seven vessels (35 days of tagging), continued in 2004 (12 vessels, 57 days) 2005 (four vessels, 23 days), and 2006 (seven vessels, 38 days). A total of 45,661 tags were released from 2003 to 2006 (Table 1). An additional 100 data tags were released on Georges Bank in June 2008 – the tags were supplied by the vendor to compensate for previously deployed tags that were incorrectly specified, using an associated yellowtail tagging project conducted by SMAST and NEFSC. Tag releases were approximately proportional to geographic distribution of yellowtail, as indicated by NEFSC surveys (Figure 1).

Table 1. Releases of tagged yellowtail flounder by stock area, tag type and year.

Year	Stock Area	Lottery Tags	$100 Tags	Data Tags	Total
2003	CCGOM	4,229	50	113	4,392
	GB	4,164	29	56	4,249
	SNEMA	778	9	34	821
2004	CCGOM	2,764	14	33	2,811
	GB	14,584	64	132	14,780
	SNEMA	1,652	14	76	1,742
2005	CCGOM	1,111	10	-	1,121
	GB	4,595	78	134	4,807
	SNEMA	627	12	-	639
2006	CCGOM	3,162	37	88	3,287
	GB	4,814	51	113	4,978
	SNEMA	2,021	13	-	2,034
2003-2006	CCGOM	11,266	111	234	11,611
	GB	28,157	222	435	28,814
	SNEMA	5,078	48	110	5,236
	All	44,501	381	779	45,661

Figure 1. Distribution of tag releases by statistical area in comparison to survey biomass.



Tank and Cage Experiments

Holding experiments were performed to assess tag retention and tagging-induced mortality. In 2004 and 2005, tank experiments were conducted to assess tag-induced mortality. On the last tow of four inshore tagging trips, 30 fish were kept in a flow-through tank on board, and transported to a flow through holding tank in Woods Hole via oxygenated shipping bags maintained at approximately 10°C. Fish were fed regularly and observed daily. One experiment observed 20 tagged fish and 10 untagged controls for 35 days. They were also held for up to a year to observe tag retention. A second experiment acclimated 30 untagged fish for 2 weeks, after which 20 were tagged. Subsamples were removed from the holding tank at durations of 0, 24 and 168 hrs. Tissue samples around the tag site were preserved and analyzed for histological reaction at the University of Maryland Fish Pathology Lab.

Results from the first tank experiment showed different patterns of mortality which suggests tag-induced mortality may be substantial, but better controls are needed. Results from the second holding experiment showed no histological reaction at the tag sites, so the mortality observed in holding experiments may not be related to tagging. The long-term holding study observed no tags lost, with some fish held for over a year.

In 2005, we received a Project Development Award of $5,500 from the Northeast Consortium to design small cages and a deployment system that can evaluate tagging-induced mortality of yellowtail flounder, a necessary component of the tagging study. Cages are cylindrical (6' diameter, 2' high), made of 1-inch coated wire mesh, with two 50” cement runners for stability. Cages were initially deployed in 24-26 fathoms. Our experimental design involved collecting yellowtail in Ipswich Bay using tagging protocol (i.e., short tows with little bycatch of other species and immediate placement in flow-through tanks). We tagged 15 fish and placed them in a cage floating at the surface by the boat. We also placed 15 untagged fish in the cage for control observations. Tagged and control fish were selected using the quality control procedures in the tagging protocol to insure that viable fish are included in the study. Cages were lowered to the bottom. Oceanographic equipment (Hydrolab©) was deployed on a cage during deployment to monitor water quality during the experiment.

After three or four days, cages were hauled to the surface to observe survival of tagged and control fish. The ratio of survival of tagged and control fish was used to estimate tag-induced mortality. Survival of all tagged and control fish is an alternative estimate of mortality that includes that trawl-capture system. Tissues were collected from five tagged fish and three control fish from each cage deployment to assess tag-induced stress. Preserved tissues will be analyzed by the University of Maryland Fish Pathology Lab for histological examination. Tissue analysis is funded by the Living Marine Resources Cooperative Research Center, associated with tank studies for yellowtail flounder. Each of the three cages was loaded with fish and deployed four times (totaling 12 deployments with 360 fish) from June 6 to 20, 2005. Cages were retrieved after three or four days. Fish were inspected for viability and condition and subsampled for tissue analysis.

Results to Date

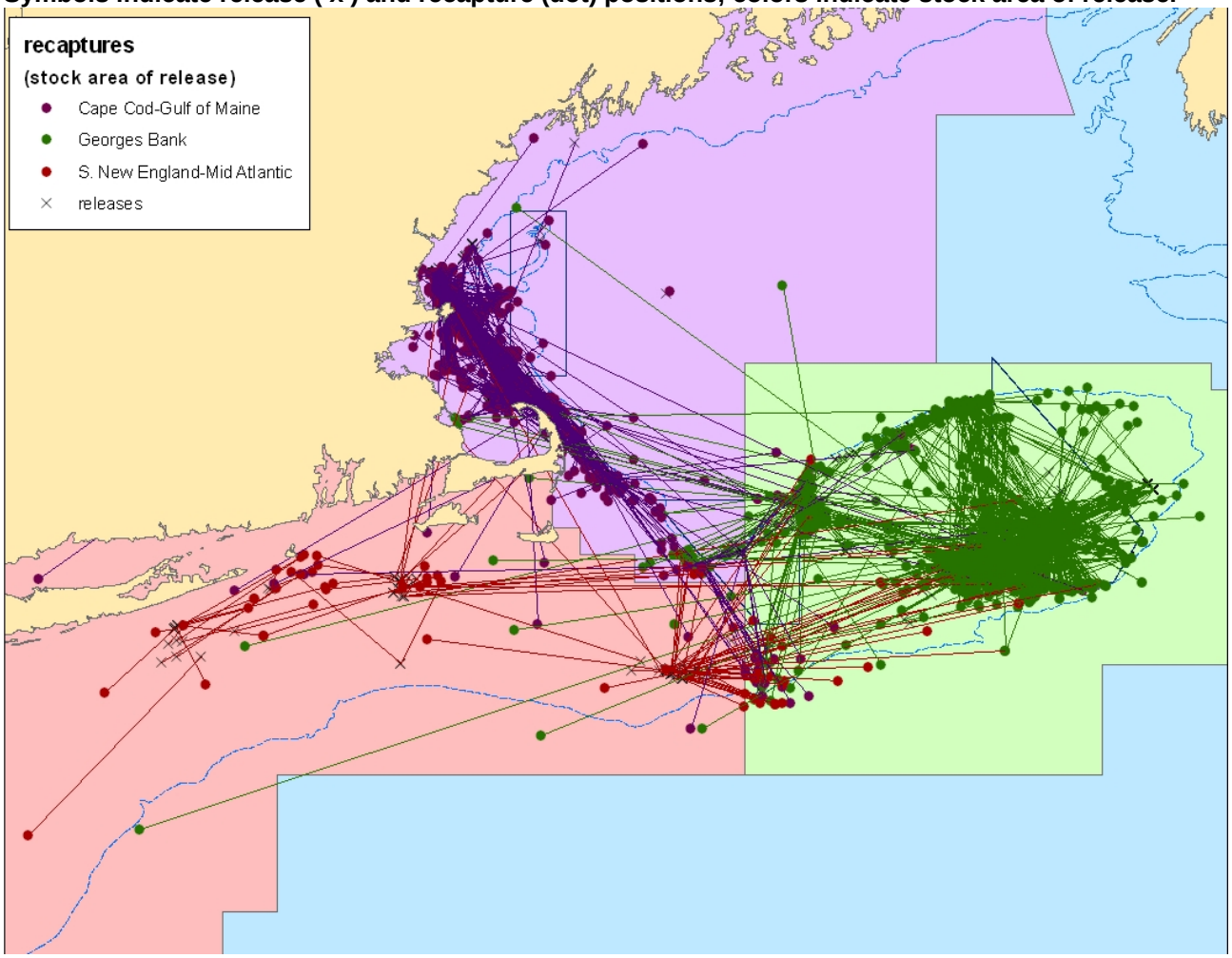
As of June 24 2008, tags from 3,734 recaptured fish were reported. Preliminary results indicate frequent movements within the Cape Cod and Georges Bank stock areas with a less frequent movement among stock areas. Recapture data with known recapture location indicates 96% residence in Cape Cod-Gulf of Maine (with 3% movement to Georges Bank and 1% movement to southern New England-Mid Atlantic), 98% residence on Georges Bank (with 1% movement to

Cape Cod-Gulf of Maine and <1% movement to southern New England-Mid Atlantic), and 48% residence in southern New England-Mid Atlantic (with 37% movement to Georges Bank and 15% movement to southern Cape Cod-Gulf of Maine; Table 2). However, most movement from southern New England to Georges Bank was from the Nantucket Shoals area (Figure 2).

Table 2. Residence and movement of tagged yellowtail flounder with respect to management areas.

Release	Recapture Stock				Recapture Stock			
Stock	CCGOM	GB	SNEMA	Total	CCGOM	GB	SNEMA	Total
CCGOM	1046	37	10	1093	96%	3%	1%	100%
GB	31	2311	9	2351	1%	98%	0%	100%
SNEMA	14	45	35	94	15%	48%	37%	100%
Total	1091	2446	1	3538				

Figure 2. Residence and movement of tagged yellowtail flounder with respect to management areas Symbols indicate release ('x') and recapture (dot) positions; colors indicate stock area of release.



Eight percent of all lottery tags have been returned; 14% of $100 reward tags and 11% of data tags were returned. The relative return rate of lottery tags to high-value tags indicates a 58% reporting rate, which is exceptional for a commercial fishery. An analysis of recapture rate by sex, size, condition code and damage code (Table 3) indicates that females had a greater recapture rate than males (particularly small males), fish categorized as 'good' had the same recapture rates as those

that were 'excellent,' and all damage codes had similar recapture rates (except 'net marks' which may be excluded from mortality analyses and 'lymphocystis' which is a natural condition).

Table 3. Recapture rate (recaptures/releases) by category.

Sex	recap/rel
female	8%
male	6%

Sex, Condition	
female, excellent	9%
female, good	8%
male, excellent	6%
male, good	6%

Female size range	
33-35cm	8%
36-38cm	9%
39-41cm	8%
42-44cm	8%
45-47cm	8%
48-55cm	9%

Male size range	
33-35cm	7%
36-38cm	5%
39-41cm	5%
42-44cm	10%
45-47cm	8%
48-55cm	9%

Condition	Recap/Rel
excellent	8%
good	8%

Damage Code	Recap/Rel
anal tear	9%
bruising	8%
ambicoloration	8%
ripe	8%
old wound	8%
fin damage	7%
sea lice	7%
abrasions	7%
fin tear	6%
anal extrusion	6%
scale loss	6%
net marks	5%
lymphocystis	3%

Analytical Results

The field protocol and analytical design were peer reviewed at "a workshop to review and evaluate the design and utility of fish mark - recapture projects in the northeastern United States" and considered to be a valid approach to address the project objectives (Tallack et al, eds. 2005). Preliminary applications of the analytical model were reviewed at the 2005 and 2006 cooperators' meetings. The few recaptures in southern New England present a modeling challenge producing extremely low fishing mortality estimates in southern New England and unrealistically high movement rates into southern New England.

Pre-GARM Analyses

Several modeling approaches were presented at a preliminary meeting of the groundfish Assessment Review Meeting (GARM; Woods Hole, August 17 2007; chaired by Paul Rago, NEFSC). Seven working papers on yellowtail tagging were presented to the group.

- *Yellowtail Flounder Tagging, pre-GARM Review* by Steve Cadrin
- *Yellowtail Flounder Movement-Mortality Model* by Steve Cadrin
- *A Simulation Approach to Evaluating the Yellowtail Flounder Movement-Mortality Model* by Larry Alade
- *Proposed Analyses for Yellowtail Flounder; a NRC Post-doctoral Research Proposal* by Anthony Wood.

- *A Spatially Explicit Stock Assessment Model of Yellowtail Flounder; a graduate research proposal* by Daniel Goethel
- *Ancillary Studies* by Larry Alade
- *Partitioning On-bottom and Off-bottom Behavior: a case study with yellowtail flounder off New England* by Josh Moser and Steve Cadrin

The primary objective of the meeting was to determine the most appropriate use of the available tagging data in the upcoming benchmark assessments for groundfish. The group decided that three aspects of the yellowtail flounder tagging project should be considered for the GARM: 1) general experimental design, ancillary studies and descriptive information, 2) results from movement-mortality model, and 3) results from pooled-stock survival analysis.

Analyses for GARM Data Meeting

Working papers were presented to the GARM data meeting (Woods Hole, October 29-November 2 2007; chaired by Robert O'Boyle). Several terms of reference were addressed by the GARM (excerpts below):

1. Do results of tagging experiments support existing stock definitions for yellowtail flounder? Cadrin et. al. (WP C5) reported the results of a large tagging study undertaken to describe the exchange amongst the Georges Bank and SNE yellowtail stocks. While they consider the results preliminary, they indicate high movement on Georges Bank but low movement between the Southern New England / Cape Cod and Georges Bank stocks. Overall, however, the study corroborated the location of the stock boundary between these components and the current stock structure of yellowtail in the GOMA.

2. Can migrations among stock areas be quantified? Cadrin (C6) also undertook modeling yellowtail tag recapture data using a formulation in which movement and mortality were considered separately. While the model showed promise, it did not adequately fit the tagging data, with significant trends in residuals in evidence. Simulations suggest that the model may not perform well when true movement rates are low, due to parameter correlations between morality and movement. It was suggested that auxiliary information, such as external estimates of fishing mortality or of movement inferred from biomass estimates from the NMFS surveys, be used to constrain model fitting. It was concluded that while the model is a possible future application for yellowtail, the current model cannot currently provide quantified estimates of migration rates.

3. Develop appropriate analytical models for estimation of migration and fishing mortality Two models were considered to estimate migration and fishing mortality rates for yellowtail stocks in the GOMA, which have extensive tagging databases available. The first model, the movement – mortality model used for yellowtail, was an update of an existing formulation which modeled movement and mortality separately. It made a number of assumptions but could not resolve model fit issues in relation to migration of yellowtail between Georges Bank and Southern New England. Thus, it was considered a preliminary formulation that required further development. An exploration of the sensitivities of this model to various assumptions on measurement and process error (Alade, C7) was instructive in identifying the model's strengths and weaknesses and guiding future work.

The second model, MARK, was also used to explore yellowtail migration and mortality processes. As with the second model, it too had difficulty fitting the yellowtail tagging data. Auxiliary data could also be useful in improving model performance. While promising, it too was considered

preliminary and not yet ready for use in the assessments. Given the difficulties that these models have encountered to date, it may instructive to model the tag-recovery data from each stock area separately to compare to the multi-stock analyses. This is the approach used in analysis of tag data from striped bass, which also uses the MARK reparameterization of the Brownie models. Also, models built on a monthly time scale may be attempting to analyze a finer timescale than these approaches were designed for, as they have been applied most commonly on an annual scale.

The tag data can also provide Petersen estimates of exploitation rate, which can be accompanied by sensitivity analysis of violations of the assumption that all recaptured high-reward tags are reported (e.g. test effect of a 90% reporting rate of high reward tags, etc.). A number of studies can be consulted which illustrate the approach, which is currently the primary analysis applied by the ASMFC Striped Bass Tagging Subcommittee and blue crab. It was noted that the models presented at the meeting can be reformulated to provide Petersen estimates. Insight on the implications of assumptions can be gained by comparing the results of different model formulations, which the NEFSC is encouraged to undertake as part of its analysis of the tagging data for this GARM.

4. Consider use of tagging data to "inform" stock assessment - It was noted at the meeting that there is a trend in fisheries population modeling to fully incorporate tagging processes within stock models. However, there is benefit to maintaining the tagging models separate from the assessment models. They provide a means to potentially estimate mortality rates independent of assumptions about the level of natural mortality required in catch-at-age models. The two modeling approaches are independent views of the same underlying processes and differences can yield insight on the veracity of the assumptions used in each. Also, the tagging data series is short and inclusion of the tagging data directly into the population model would imply a relatively low contribution to the likelihood function of the stock models.

GARM Assessment Methodology Meeting Analyses
Working papers were also presented to the GARM models meeting (Woods Hole,February 25-29 2008; chaired by Robert O'Boyle). Several terms of reference were addressed by the GARM (excerpts below):

For certain stocks that are aged, utility of statistical catch-at-age vs. VPA based models with respect to Retrospective patterns, Flexibility to account for alternative parameterizations, Ability to incorporate external sources of information, especially tagging and environmental data and Ability to estimate parameters incorporating prior, external information - When competing hypotheses of partial recruitment are being considered, all information, including external sources of data, should be examined to inform the merits of each. For example, it may be possible to disaggregate the plus group catch to assist in hypothesis testing. Analyses of tagged fish presented at the meeting offered promise for evaluating hypotheses about partial recruitment. A number of different hypotheses emerged at the meeting that could be formally investigated which the Panel encouraged. A domed fishery partial recruitment is at odds with the results of tagging analysis presented at this meeting, which suggested no dome. There was discussion at the meeting on the potential confounding of the tagging results by other processes (e.g. gear avoidance, emigration, tag reporting rate), and although none of these appeared likely, there was insufficient time at the meeting to fully explore the alternatives. Thus, while a domed partial recruitment on the older age groups appears unlikely, further exploration of external data could be undertaken to corroborate this.

Tag retention and Tag-Induced Mortality

Results from the cage experiments indicated low overall mortality of tagged and control fish. Of the 360 fish in the experiment, only 15 died, and more control fish died than tagged fish. Six fish died in the second deployment, which was associated with poor weather conditions and cage movement. Therefore, it appears that the trawl-capture and caging system impose more mortality than tagging. Analysis indicates no tag-induced mortality, because more control fish died than tagged fish, and approximately 3% mortality from the capture and cage system. Removal of data from a cage where sandfleas were observed eating live fish, suggests a 1% mortality from the trawl-capture system.

The cage experiments were considered so successful and efficient that they were also conducted on Georges Bank in summer 2005. Although deploying cages offshore was more difficult, results also suggested low to negligible tag induced mortality. In 2006, cage experiments were conducted with each release event to improve estimates of tag-induced mortality. Preliminary results confirm a minimal tag-induced mortality.

Data-storage tags

Eighty-three data-storage tags were returned, indicating distinct off-bottom movements (Cadrin and Moser 2006). All tags at large more than one month indicated distinct off-bottom movements. Off-bottom movements were typically in evening hours, between 18:00 and 22:00, lasting an average of four hours, ascending to an average of 15m off-bottom (Cadrin and Westwood 2004). The frequency of off-bottom movements varied geographically, an average of once every ten days off Cape Cod, and once every three days on Georges Bank.

These results illustrate how archival tags enhance the interpretability and power of tagging studies. Until recently, the well-studied yellowtail flounder was thought to be a "sedentary" fish, feeding on epibenthic fauna and limited to relatively shallow, sandy habitats. This strict habitat preference and the discontinuous distributions of such habitats were considered to limit movement among offshore banks and shelves, thereby maintaining geographic stock structure. The movement patterns indicated by disc tags likely involves passive drift in midwater currents, similar to patterns observed for other flatfish species. Therefore, the use of electronic tags reveals an important aspect of yellowtail behavior that was not apparent after decades of intense research.

Data

Modifications and improvements to the existing yellowtail flounder tagging database were made. The 2003-2006 tagging data underwent rigorous quality control procedures, resulting in the correction of many data entry errors. This process, although time consuming, improved the quality of the existing data and resulted in changes to the structure of the database.

Several data fields were added to improve our ability to quickly summarize the release and recapture data and generate GIS maps for outreach. The individual tag release records have been linked to the tow data, resulting in location information for every tag. The quality of the recapture data has been greatly improved through this process. Vessel hull numbers have been added to keep better track of participating vessels. A lookup table has been added that produces the statistical area where fish were recaptured. The addition of fields for data quality coding (i.e.: recapture data and recapture location) has enabled the data to be filtered by quality of data.

The structural changes to the database lead to modifications of our field protocol. The field data sheets were re-designed and preparations for field work were changed to further improve data collection at sea. The data sheets now have record numbers for each fish tagged, tag series are assigned to scientists to improve record keeping, and standardized comment codes related to fish condition have been added. Additionally, prior to field work, tags are organized in sequential order for deployment to minimize recording errors. These changes have greatly improved the quality and efficiency of data collection in the 2005 tagging season.

The transition to a relational database will greatly improve our ability to analyze these data. In the future, we will be able to link to other NEFSC databases such as the weighout and logbook data. Additionally, the yellowtail flounder data are being used as a model for the design of a multi-species mark-recapture database which will house data from all NEFSC tagging projects.

Data from tag releases and recaptures are continually being added to the yellowtail tagging database. When the project is complete, a comprehensive database will be provided to the Consortium. Preliminary data can be provided upon request. The Northeast Fisheries Science Center has dedicated resources to maintain the yellowtail tagging database indefinitely as a part of the NEFSC Mark-Recapture Database System (MRDBS).

Impacts and Applications

The results from this study are benefiting researchers and managers, helping to improve the management of yellowtail resources. New information on yellowtail movement, independent estimates of mortality and confirmation of age determinations are useful for academic, state, and federal scientists and will be important information for fishery managers (i.e., the New England Fishery Management Council). The cooperative approach used in the experimental design is being continued throughout the data collection, analysis and interpretation stages of the study. Therefore, results and conclusions are a product of all cooperators.

Co-principal investigators and other cooperators met annually from 2003 to 2006 to review results to date. Results are posted on the website (cooperative-tagging.org) and presented to stock assessment workshops (e.g., GARM, SAW, TRAC), management meetings (e.g., groundfish committee) and industry groups (e.g., fishermens' forum, Fish Expo) in the form of technical reports and visual presentations. Estimates of mortality and movement, as well as growth confirmations are being evaluated in the 2008 benchmark assessments of all yellowtail flounder stocks, for consideration in the determination of stock status.

Related Projects

This study was designed to complement the programmatic surveys and fishery sampling for yellowtail flounder stock assessments. It is coordinated with the Southern New England yellowtail tagging studies conducted by the School for Marine Science and Technology, and the Yellowtail Industry Based Survey funded by NMFS Cooperative Research Partners Program. The tagging funded by the Northeast Consortium continues the initial yellowtail tagging funded by NMFS Stock Assessment Improvement Program in 2003. Tagging protocols, material and results are shared with Canada Department of Fisheries and Oceans to provide observations on eastern Georges Bank for the cooperative study. The holding studies are supported by a separate project development grant from the Northeast Consortium, and histological analyses are supported through a Living Marine Resources Cooperative Research Center grant.

Partnerships

The greatest resources available to the project are its personnel. Fishermen and researchers have cooperated to develop the general approach and technical details of the tagging study through several meetings from Rhode Island to Maine. All cooperators were invited to three meetings to reflect on field work, review results and plan future work. Six fishermen and 33 scientists attended the first meeting in Woods Hole on January 14, 2004. Seven fishermen and 29 scientists attended the second meeting in Woods Hole on May 2, 2005. Twenty-one fishermen and 13 scientists attended the third meeting in New Bedford on March 1, 2006. Detailed summaries of the meetings are available online (www.cooperative-tagging.org).

Co-Principal Investigators

Steve Cadrin, NOAA/UMass CMER Program, New Bedford MA

Steve has been a fisheries biologist for 20 years, and is responsible for stock assessments of yellowtail flounder. Steve's Ph.D. dissertation was "Stock Structure of Yellowtail Flounder."

Azure Westwood, Northeast Fisheries Science Center, Woods Hole MA

Azure is a marine biologist who was under contract with NEFSC to coordinate cooperative research on yellowtail flounder. Azure has experience in community-based fisheries science and management from American Samoa, Alaska and New England.

Larry Alade, NOAA Educational Partners Program, Woods Hole MA

Larry has been involved with the yellowtail tagging program as a graduate intern, doctoral student, and now as a NEFSC scientist. Larry' Ph.D. dissertation is "Impact of spatial structure on the movement mortality model and its application to Yellowtail flounder."

Josh Moser, Northeast Fisheries Science Center, Woods Hole MA

Josh is experienced in managing various fish tagging programs, including recent studies of black seabass and scup movement and mortality. Josh has also experienced in analyzing data from electronic tags.

David Goethel, F/V Ellen Diane, Hampton NH

David is a Gulf of Maine groundfish fisherman with experience in cod tagging and cooperative research. David has also helped in the experimental design and will continue to help with outreach in the Cape Cod-Gulf of Maine area.

Fred Mattera, F/V Travis & Natalie, W. Kingston RI

Fred is a highliner in the offshore yellowtail fishery and has been instrumental in the development of the industry-based survey for southern New England yellowtail. Fred also provided input for the initial tagging study design and continues to be involved in project management.

Other fishermen who have been involved in tagging and attending planning meetings: Carlos Ageuas (F/V Victory), Bill and Jason Amaru (F/V JoAnne-A III), Rodney Avila Sr. and Rodney Avila Jr. (F/V Trident), Bruce Bannick (F/V Sarah Beth), Ed Barrett (F/V Phoenix and F/V Sirius), Antonio Barroqueiro (F/V Lady of Grace), Tom Bell (F/V Karoline Marie), Tony Borges (F/V Sao Paulo), Ron Borjeson (F/V Angenette), Carl Bouchard (F/V Stormy Weather), Ray and Rich Canastra (Whaling City Auction), Luis Fidalgo (F/V Vila De Ilhavo), Steve Follette (F/V Heather Lynn), Jim Ford (F/V Lisa Ann II), Paul Harvey (F/V Ing Toffer II), Manny Marquintos (F/V Victory), Luis Martins (F/V Victory), Shawn McLellan (F/V Elizabeth), Maggie and John Raymond (F/V Olympia), Luis Ribas (F/V Blue Skies), Dennis Robillard, Jr. (F/V Julie Ann) and Jaime Santos (F/V Lady of Grace), Tracy Stubbs (F/V Ing Toffer II) and Proctor Wells (F/V Tenacious), and dozens more have returned tags.

Cooperating Research Agencies

Many people are collaborating on this study and have contributed to its design:

- *NMFS*: Steve Murawski, John Boreman, Frank Almeida, Fred Serchuk, John Hoey, Paul Rago, Tony Wood, Talia Bigelow, Stacy Kubis, Gary Shepherd, Bill Overholtz, Nathan Keith, Jonathan Duquette, Rob Johnston, Kevin McIntosh, Bill Duffy, Dave Radosh, Chris Legault, Jay Burnett, Sarah Pregracke, Vaughn Silva, Patricia Yoos, Heather Sagar, Earl Meredith, Sarah Babson-Pike, Mike Palmer , Steve Kelly, Erin Kupcha, Katie Lovett, Joe Mello, Anthony Morales and Chris Zanni.
- *MADMF*: Jeremy King, John Boardman, Brian Kelly and David Pierce
- *SMAST*: Dave Martins, Jess Melgey, Dan Goethel, Jon Loehrke, Greg DeCelles, Sally Roman, Adam Barkley, Rodney Rountree, Joachim Gr eger, Russ Kessler and Darin Jones
- *RIDFW*: April Valliere and Sarah Pierce
- *Canada DFO*: Heath Stone
- *University of Maryland*: Eric May, Andrea Johnson and Erica Anuszewski
- *Northeast Consortium, University of New Hampshire:* Chris Glass, Rachel Gallant
- *Manomet Center*: Greg Morris and Kris Joppe-Mercure
- *REMSA Observers:* Janine L'Heureux and Meryl Segal

In addition to personnel resources (including all scientific field staff), the proposed study has the support of the Northeast Fisheries Science Center, providing data (e.g., the commercial weighout database, logbook data, observer program information, and the NEFSC survey database) computational hardware and software, toll-free phone support, website maintenance, and scientific research permits. Industry representatives have the ability to communicate the objectives of the project to other yellowtail fishermen, thereby maximizing the potential reporting rate of recaptured tags.

Presentations

- Azure Westwood was awarded 'Best Poster' at the 2004 International Council for the Exploration of the Seas Annual Science Conference (September 19-29 2004, Vigo Spain) for the poster "The use of electronic tags to study fish movement: a case study with yellowtail flounder off New England."
- Steve Cadrin presented "Movement of Yellowtail Flounder: A Cooperative Tagging Study" at the Ninth Flatfish Biology Conference (December 1 2004, Westbrook CT).
- Steve Cadrin presented "Tagging Yellowtail Flounder with Commercial Fishermen" at the 61st Northeast Fish and Wildlife Conference (April 17-20 2005, Virginia Beach VA).
- Larry Alade presented "Application of a Mark and Recapture Model to Historical Data for Yellowtail Flounder off New England" and "A Pilot Study on Tag-induced Mortality of Yellowtail flounder (*Limanda ferruginea*)" at the 2005 American Fisheries Society Annual Meeting (September 2005, Anchorage AK)
- Steve Cadrin presented the keynote address for AFS Southern New England Chapter meeting "Advanced Technology for Fishery Science: experiences with archival tagging" (6/14/06 Fall River MA).
- Larry Alade presented "Performance of a movement-mortality model on simulated Yellowtail flounder data" at the 2006 American Fisheries Society Annual Meeting (September 2006, Lake Placid NY)
- Steve Cadrin presented "Implementing a more holistic approach to cooperative research" at the ICES symposium on Fishing Technology in the 21st Century (November 2006, Boston MA).
- Steve Cadrin presented a keynote address, "Bridging disciplinary gaps for ecosystems science through collaborative research, advanced technologies and education" at the 2007

AFS Symposium on How to Implement Integrated Ecosystem-Based Management in Fisheries (September 2007, San Francisco CA).

- Steve Cadrin presented "Studying movement of yellowtail flounder with electronic tags" at the 2007 AFS Symposium on "Use of tagging Technology for Ecosystem Studies (September 2007, San Francisco CA).

Student Participation

- Larry Alade graduated from the University of Maryland Eastern Shore (May 2008) and developed the tagging model for yellowtail flounder as his doctoral research under the NOAA Educational Partnership Program.
- Daniel Goethel is a Masters student at University of Massachusetts School for Marine Science and Technology developing a spatially explicit stock assessment model of yellowtail flounder metapopulation analysis of yellowtail flounder.
- Jessica Melgey is also a Masters student at University of Massachusetts School for Marine Science and Technology working on estimation of yellowtail flounder abundance using a mark-recapture experiment.
- Henry Jackson was an undergraduate student at Jackson State University who provided technical support for the 2004 holding study as a NEFSC summer intern.
- Erica Anuzewski is an undergraduate student at the University of Maryland Eastern Shore working on the 2005 holding study as a LMRCRC intern.
- Jon Loehrke, Greg DeCelles, Talia Bigelow, Sally Roman and Adam Barkley are students in the NOAA/UMass CMER Program, assisting with yellowtail tagging.

Published Reports

Cadrin, S.X. and J. Moser. 2006. Partitioning On-bottom and Off-bottom Behavior: a case study with yellowtail flounder off New England. ICES CM 2006/Q:14.

Cadrin, S., G. Shepherd, T. Sheehan, S. Kubis, J. Moser, A. Westwood. 2007. Using information from electronic tags for stock assessment of northeast fishery resources. pp 60-61 In Workshop on Advancing Electronic Tag Technologies and Their Use in Stock Assessments. NOAA Tech. Mem. NMFS-F/SPO-82.

Cadrin, S.X. and A.D. Westwood. 2004. The use of electronic tags to study fish movement: a case study with yellowtail flounder off New England. ICES CM 2004/K:81 (available online http://www.ices.dk/products/CMdocs/2004/K/K8104.pdf)

Cadrin, S., A. Westwood, L. Alade, N. Keith, R. Rountree, D. Martins, R. Kessler, D. Jones, A. Valliere, J. King, J. Boardman, H. Stone and New England Fishermen. 2004. Movement of Yellowtail Flounder: A Cooperative Tagging Study. Pp 13 in Ninth Flatfish Biology Conference. NEFSC Ref. Doc. 04-13. (available online http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0413)

Recksiek, C.W., G. Fischer, H.T. Rossby, S.X. Cadrin, and P. Kasturi. 2006. Development and application of 'FRAFOS' tags for studying fish movement. ICES C.M. 2006/Q.

Shepherd, G., S. Cadrin, J. Moser, A. Westwood and S. Kubis. 2007. Application of electronic data storage tags in studies of black sea bass and yellowtail flounder in the Northwest Atlantic. pp 43-44 In Workshop on Advancing Electronic Tag Technologies and Their Use in Stock Assessments. NOAA Tech. Mem. NMFS-F/SPO-82.

Tallack, S., Rago, P., T. Brawn, S. Cadrin, J. Hoey, and L. Taylor Singer. 2005. Proceedings of a workshop to review and evaluate the design and utility of fish mark - recapture projects in the northeastern United States. NEFSC Ref. Doc. 05-02. (available online http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0502)